

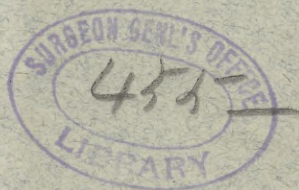
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ON THE BINOCULAR METAMORPHOPSIA
PRODUCED BY CORRECTING
GLASSES

BY

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ON THE BINOCULAR METAMORPHOPSIA PRODUCED BY CORRECTING GLASSES.

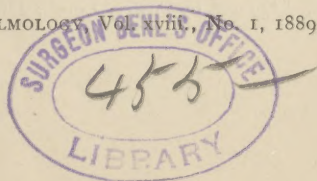
By J. A. LIPPINCOTT, M.D., PITTSBURG, PA.

IN a recent number ¹ of the *Journal of the American Medical Association* appeared an article (by Dr. H. Culbertson) which had been read before the Ophthalmological Section of the Association in May of last year, describing certain apparent changes in the forms of objects observed by some persons after the correction of astigmatism of one or both eyes.

These changes were, in the article referred to, stated to be seen in regarding comparatively near objects, and only in binocular vision. A rectangular board, at the distance of a metre, appeared to be wider at one end than the other, and the floor seemed to slope to the right or left. With either eye singly, the phenomenon was not noticed. On rotating the cylinders a few degrees, the objects again appeared normal, and the radiating test lines of equal distinctness. These apparent changes were attributed by the author of the article to a want of muscular balance, owing to which, in using both eyes, one eye (or both) rotates more or less on its antero-posterior axis, thus necessitating a corresponding rotation in the correcting cylinders; and this change in the eyes he denominates "binocular astigmatism."

Now the phenomena noticed began to attract my attention, and what I conceive to be the true mode of their production occurred to me a number of years ago; but the

¹ Nov. 3, 1888.



matter did not seem to be of such engrossing importance as to develop an attack of *cacoethes scribendi*. The publication of the above-mentioned article, however, illustrating, as I believe it does, the fact that an unscientific hypothesis is apt to be followed by improper treatment, prompts me to commit my reflections on the subject to paper.

The literature of the subject is, so far as my opportunities for investigation have gone, conspicuous by its absence. Donders, Stellwag, and other systematic writers speak of the effect of glasses in changing the form of retinal images, and Knapp,¹ in pointing out the features of irregular astigmatism, mentions *inter alia* metamorphopsy—straight lines appearing curved, etc. But it is evident that monocular phenomena are referred to, and I can find no allusion to an apparent change in the forms of objects produced by correcting refractive aberrations, this change necessitating, as an essential condition, the existence of binocular vision. How necessary the latter is will, I think, appear in the course of this paper.

The hypothesis of a change in the position of the meridians of the astigmatic eye, either from rotation of the globe incident to muscular incoördination, or from a modification of the lenticular curvature incident to the act of accommodation, is, in my judgment, not satisfactory for the following reasons: (1) In the rather rare cases of actual paralysis or paresis in which there is an abnormal rotation of the globe, the abnormality evidences itself, and the relations of the objects are changed *spontaneously*; and no correction of an existing refractive error is required to bring out the defect. (2) The cases in which the astigmatic meridians occupy one position in distant and another in near vision, however the change may be brought about, are exceedingly rare; and, moreover, in such cases binocular vision plays no necessary rôle. (3) A fairly normal appearance of the radiating test lines after rotating the correcting cylinders in order to obviate a supposed rotation of the globe, by no means demonstrates a real correction of the astigmatic defect, because each eye supplements the other, and the deficiencies of each are thus

¹ Quoted by Power, Lond., 1868, p. 614.

neutralized or veiled. (4) The phenomena with which we are concerned are not rare, not even comparatively rare. On the contrary, they are to be seen in all cases of anisometropia with binocular single vision, with exceptions to some of which allusion will be made. The existence of an astigmatic defect is not a *sine qua non*, although the phenomena are especially noticeable in cases of astigmatism of one or both eyes, in which the chief meridians are oblique.

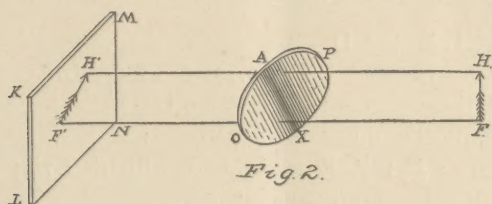
When both eyes require cylinders of the same degree, the axes must be unparallel. When the glasses correspond in strength, and the axes in position (actual isometropia), any obliquity of the latter is compensated for by turning the head, and the observed objects are thus prevented from assuming an unnatural appearance.

For the production of the phenomena described in this paper binocular single vision is necessary, because a means or standard of comparison is essential, and, as is well known, the field of accurate binocular fusion is quite limited, the mind receiving information from each eye, separately, in regard to its own side of all but very small objects.

Before generalizing further on the subject of binocular metamorphopsy, it will be proper to illustrate some of its manifestations. These manifestations may, for sake of simplicity, be divided into two groups: (1) Those characterized chiefly by an alteration in the relative dimensions of the top and bottom of the object—*unparallelism of the sides*. (2) Those characterized chiefly by an alteration in the relative dimensions of the two sides—*unparallelism of the top and bottom*.

Group I.—Top wider or narrower than bottom. (1) Suppose A., who rejoices in binocular single vision, requires, and is furnished with, R E + 1 D, L E + 1.25 c, axis 60°. On looking at a perfectly rectangular book, held upright, at ordinary reading distance, the right side of the book looks natural and perpendicular, whereas the left side appears to slope upwards and to the right, so that the top of the book seems to him narrower than the bottom. (2) Suppose R E fitted with + 1 D and L E with + 1.25 c, axis 105°, the right side of the book is normal, while the left side slopes

towards the proximal side, KL, of the surface KLMN, to the point H.¹ Similarly a ray starting from F will come within the influence of the prism AOX, and will be deflected towards the distal side, MN, to the point F.¹ Again, if in fig. 2 PAOX be a simple concave cylinder, thus consisting



virtually of two prisms whose bases lie towards P and O, it is plain that the ray HH' will be deflected by passing through the prism APX towards the distal side MN, while the ray FF' will be refracted towards KL. Hence the image on the surface KLMN is inclined instead of vertical. It may be added that the deflection of the rays will be greater in proportion as the cylinder is stronger, and in proportion as the axis approximates the position midway between vertical and horizontal.

Let us suppose KLMN, in fig. 2, to represent the retina of an emmetropic left eye before which is placed the — cyl. PAOX. In the retinal image the arrow-head will point downwards and to the left, and, by the well-known law, the mental image will be projected in the opposite direction, so that the arrow will appear to be inclined upwards and to the right.

Now, we may, for our present purpose, consider an eye affected with simple HAS as equivalent to an emmetropic eye with a concave cylinder, such as PAOX (fig. 2), placed in front of it. In like manner we may regard an eye affected with MAS as equivalent to an emmetropic eye with a convex cylinder, such as PAOX (fig. 1), in front of it. Hence, in a case of astigmatism, axis oblique, the image of a vertical line occupies not a vertical but an oblique position on the retina; and hence, in such a case, there ought to be an apparent inclination of one or both sides, as the

case may be, of a square. To this part of the subject we shall return.

Group II.—Characterized mainly by a change in the relative heights of the two sides. This group may, for sake of convenience, be divided into two sub-classes: *Sub-class (a).* *Anisometropia without astigmatism.* Examples:

R E plano, L E + 1 D. The left side appears wider. Or, to quote from my records, R E - .75, $S = \frac{20}{xx}$, L E emmetropic, $S = \frac{20}{xx}$. R E reads best with a plano, L E with + .75; left side appears wider. To quote another case: R E + .25, $S = \frac{20}{xx}$; L E + 2.5, $S = \frac{20}{xxx}$; R E reads best with + 1.75; L E with + 4 D. Left side appears much wider.

As in Group I, experiments with emmetropes confirm the results of clinical observation, and show that if spherical glasses of differing degrees be placed before the eyes, the side of the object corresponding to the higher refractive index appears to be wider; and, furthermore, that the difference in width is proportionate to the difference in the indices of the lenses. *Sub-class (b).* *Unilateral or bilateral astigmatism*, but having a different *modus agendi* from astigmatism, as illustrated in Group I. It may be here remarked, that several years ago, when my attention was in the first place drawn to this subject, only the phenomena represented by Group I presented themselves clearly to me, the explanation, which then suggested itself, being amply corroborated by my record books. The matter was then gradually allowed to drop, and it was not until recently that the subject was again taken up, with the results illustrated by Group II. For this reason, although such cases as those given in sub-class (a) of Group II are numerous enough, typical clinical material coming under sub-class (b) is not, so far, abundant. From the cases which I have had the opportunity of examining during the past few weeks, I select the following:

(1) Miss McC. æt. twenty-two, R E + .5 c. vert., $S = \frac{20}{xx}$; L E plano, $S = \frac{20}{xx}$; right side wider. (2) S. P. B., R E emm., $S = \frac{20}{xx}$; L E + .5 c. vert., $S = \frac{20}{xx}$; left side wider. (3) Miss M, W., æt. fifteen, R E + 1.25 Sp, $S = \frac{20}{xx}$; L E + 1.5 c., 103°.

$S = \frac{20}{xx}$; left side appears wider than right. (4) Mrs. W., æt. forty-seven, R E + 1. Sp. - 4. c., axis hor., $S = \frac{20}{xl}$; L E + .5 - 3. c., 24° , $S = \frac{20}{xl}$; R E reads best with + 4 c. vert., L E with + .75 + 3. c., 114° . Thus right side appears somewhat wider. (5) H. J. K., æt. thirty, R E - .5, $S = \frac{20}{xx}$; L E - .5 - 1.75 c. vert., $S = \frac{20}{xx}$; R E reads best with a plano, L E with - 1.5 c. vert. Thus the right side appears much wider than the left.

From the above-cited cases it may be observed that if a + cylinder, ax. vert., be placed on one eye, and a plano [cases (1) and (2)], or a comparatively weak spherical [case (3)] on the other, the side corresponding to the cylinder appears wider. Case (5) shows that, on the other hand, a - cylinder with axis vertical has the effect of diminishing the width of its side.

The effect of convex and concave cylinders, with axes vertical, horizontal, and oblique, on the relative heights of the right and left sides of a square, was investigated in a considerable number of experiments with emmetropic eyes, and, while the results hinted at above were confirmed, the facts elicited were in some respects so unexpected, and, moreover, so suggestive, that it may be proper to briefly state them: (α) A + cyl. vertical, or a - cyl. horizontal, before either eye, widens the corresponding side of a square. (β) A - cyl. vert., or a + cyl. hor., narrows the corresponding side. (γ) If the cyl. (+ or -) is placed vertical, its effect is much greater than when placed horizontal.

The magnifying effect of a + cyl. progressively diminishes as the axis is turned away from the vert., until a point is reached midway between the vertical and horizontal (45° or 135°), at which point it is nil. If the movement of the axis be continued, a minifying effect is instituted, which progressively increases till the horizontal is reached. Precisely the converse takes place in employing a minus cylinder. (δ) The narrowing or widening increases with the strength of the cylinder (+ or -), until the latter is so strong that the image is blurred sufficiently to be suppressed mentally, and monocular vision in this way practically established. (ε) Lastly, while the effect of a given cylinder in the same position is not absolutely uniform in

different persons, nor even absolutely constant in the same person, the following table, which represents the results of a number of experiments, will probably be generally found very nearly exact. It is scarcely necessary to explain that on one side of the equation is placed the cylinder, and, on the other, the spherical glass which restores equality in height to the two vertical sides of the square.

(a)	L E + 1 D c,	vertical	=	R E + 2.25
(b)	" - 1 D c,	"	=	" - 1.75
(c)	" + 1 D c,	horizontal	=	" - .75
(d)	" - 1 D c,	"	=	" + 1.25

From the above it will be seen [(a) and (d)] that a + cyl. vert. magnifies about twice as much as a - cyl. hor.; and that a - cyl. vert. diminishes about twice as much as + cyl. hor. If, then, one or both of the eyes be fitted with vert. or hor. cylinders, and if the two lenses bear to each other the relation given in the above table, there will be no metamorphopsy, notwithstanding the anisometropia. As already intimated, the effect of a + cyl. progressively decreases as it is turned from vertical to 45° or 135° , as shown in the following table:

+	1,	vertical	L E	=	+ 2.25	R E
"	105°	"	"	=	+ 1.65	"
"	120°	"	"	=	+ .75	"
"	135°	"	"	=	0	"

Thus if L E be fitted with + 1 c. vert., and R E with + 2 c, 115° , the top and bottom of the square may be parallel, but meta-morphopsy will result, as illustrated by the cases in Group I.

An explanation of the cases coming under sub-class (a) of Group II is scarcely required. Donders (Syd. Soc. Ed., p. 152) shows that a convex glass placed before the eye, by moving the nodal point forward, enlarges the retinal image, while a concave glass, by moving the nodal point backward, diminishes the retinal image. But to explain the phenomena illustrated by the cases in sub-class (b) is a rather more difficult task, *e. g.*, a + 1 cyl., axis vert., held before the left eye, the right being covered, while it increases the width, cer-

tainly does not increase, rather seems to diminish, the height of a square. Nevertheless, if the right eye be uncovered, the left side at once appears markedly higher.

In like manner a — 1 cyl., ax. vert., before L E, R E being covered, appears to increase, rather than diminish, the height of a square; but, on uncovering the right eye, the left side seems markedly lower. So also, *a priori*, a + cyl., axis horizontal, ought to increase, instead of diminishing, the height of its side, while a — cyl., axis horizontal, ought to act in a contrary manner.

There are some reasons for supposing the explanation to be connected in some way with accommodation. Donders (p. 155) has shown that if the accommodative tension is relaxed, objects appear larger, because the mind conceives them to be at a greater distance. Besides, experiments do not give entirely uniform results in the same person. Indeed, at times the effect of the cylinder is not always obvious at the first glance, depending somewhat perhaps on the personal equation; and it changes from moment to moment as we look. Furthermore, the effect is most manifest at the reading distance—the point where accommodation is most exercised. On the other hand, it would seem that the mechanical change in the dioptric apparatus, known as the accommodative act, is not an essential factor, because in a number of thoroughly atropinized eyes precisely the same results, both in kind and degree, followed the use of cylinders, as are stated above to have been observed in non-atropinized eyes, whether astigmatic or emmetropic. It is possible, however, that the explanation of the phenomena lies in a change, produced by cylindrical lenses, in the dynamical or mental element of accommodation—in the *accommodative impulse*.

If this view be correct, we must, in order to account for the facts, assume that the accommodative impulse is affected in the cases under consideration unequally on the two sides; and, furthermore, that the degree to which, and the manner in which, it is affected vary according to the position of the axis. *E. g.*, a + cyl., vert., must markedly relax, while — cyl., vert., must markedly stimulate, the accom-

modative impulse of the eye before which it is placed, as compared with its effect on the other eye. Conversely, a $+$ cyl., hor., must exert a stimulating, while a $-$ cyl., hor., exerts a relaxing influence.

When the axis of the cylinder is vertical, and therefore the transmission of rays lying in a vertical plane uninterfered with, the full extent of this relaxation or stimulation is shown; but when the axis of the cylinder is horizontal, the influence on the accommodative impulse is partially neutralized by the action of the glass itself. *E. g.*, a $+$ 1 cyl., hor., before left eye diminishes the height of the left side of a square *less* than the same cylinder, vert., increases it, because a $+$ cyl., hor., before one eye (the other being closed) increases the height of objects, and to that degree lessens its binocular diminishing effect. Similarly a $-$ 1 c., hor., L E, increases the height of the left side *less* than a $-$ 1 c., vert., decreases it, because such a cylinder, monocularly used, diminishes the height, and so partially neutralizes its binocular magnifying effect.

The appearances under discussion might possibly be explained, though, to my mind, not so satisfactorily as in the manner above indicated, in the following way. The estimation of the height of each side is relegated to the eye on that side, whereas horizontal measurement is a common ground for the action of the two eyes. Now a $+$ cyl., vert., L E, increases the horizontal dimensions on the left side: and the relation established by the right eye between vertical and horizontal measurements, being transferred to the left side, makes it appear magnified vertically, because it is magnified horizontally.

In what mode soever the phenomena of metamorphopsia are produced, they are very rarely consciously observed *spontaneously*. Hence, doubtless, the lack of attention devoted to the subject. With very few exceptions, the only persons, in my experience, who, after correction of their anisometropia, have complained of irregularity in the forms of objects, have been artists. This is a curious illustration of the extreme rarity of accurate observation. But, seldom as the patient speaks of the matter of his own

accord, if his attention is drawn to the subject, it is generally easy, by indirect suggestion, to make the apparent form-changes visible to him. *E. g.*, when the conditions required are present, the patient may be asked if he observes any peculiarity about the book. Sometimes he responds at once: "Oh, yes, it is wider at the top." More frequently, however, he replies: "I see nothing peculiar but the clearness of the type." He may then be asked (*e. g.*, in a case in which the left side of the square ought to look wider than the right): "Don't you think the right side of the page looks wider?" The patient, after a moment's consideration, will reply: "No, it is narrower"; and he is surprised that he did not notice it before. On the other hand, I have seen persons who were made dizzy, even to faintness, by the tipsy appearance of doors and windows; and it is not unreasonable to attribute, in part at least, to this distortion of retinal images, the discomfort which many persons experience, without being able to explain why, on being furnished with glasses which we feel sure are correct in every respect.

It has already been stated that, in a case of astigmatism, with axis oblique, there ought to be an apparent inclination of one or both sides, as the case may be, of a square; that objects, therefore, and their retinal images do not correspond in form. Experience, however, derived especially through the sense of touch, enables the mind to correct the erroneous information furnished by the sense of sight. In other words, inaccurate retinal images are translated into more or less accurate mental impressions. In adjusting his relations to external objects, in finding the haven of correct knowledge with so untrustworthy a compass to guide his search, what rocks and shoals the anisometropic child runs into, what falls and bruises he encounters from sloping floors, distorted furniture, and erratic stairways, none can know, since the educational process he is doomed to go through is an unconscious one. But a field of observation is here opened up which might repay investigation. For example, in children who are constantly stumbling and falling, it might be well to endeavor to discover whether the conditions of metamorphopsy are not realized.

Once the habit of correction is formed, and approximately accurate notions of form, notwithstanding the imperfection of the retinal images, are obtained, if the refractive defect be corrected, the mind, under the influence of habit, *over-corrects*, and the result is that, whereas an oblique retinal image gave the mental impression of a rectangular object, the corrected and rectangular retinal image gives the mental impression of a non-rectangular object. In this way the sides of the book appear to slope, and the top appears wider than the bottom, etc.

In regard to the more practical aspects of the subject of this paper, it may be remarked that as metamorphic vision depends on the formation of a mental habit, so its remedy consists in breaking up this habit; and it is probable that this end can be attained, at least fully enough to prevent serious annoyance, within a few months by the persistent use of the correcting glasses. The following case is interesting, as showing what can be done in this direction :

Miss S. K., æt. twenty-four, artist, examined under atropine September 10, 1886. R E $-1-.75$ c., vert., $S=\frac{2.0}{xx}$; L E -1 , $S=\frac{2.0}{xx}$ R. E reads best $+.75$ c., hor., L E $+.75$. Franklin glasses were ordered as follows: Above, full correction; below, R E $+.75$ c., hor., prism 2, inwards; L E $+.75$, prism 2, inwards. December 5, 1888: Has worn the glasses constantly, and has painted almost incessantly without inconvenience. With the glasses on, a square card looks perfectly natural. On removing the glasses, the *right* side appears decidedly wider.

This patient has thus been restored by the use of correcting glasses to a veritable "state of nature,"—to the condition in which she found herself when she first began to use her eyes, and before the educational process spoken of above was commenced. On the other hand, when the glasses are worn only for near vision, it is doubtful whether the metamorphopsia ever entirely disappears, although it may be somewhat lessened in degree.

W. C., æt. thirty-two, examined October 17, 1887. R E $+.25+.5$ c., vert., $S=\frac{2.0}{xx}$; L E $+.25$, $S=\frac{2.0}{xx}$. Reads best R E

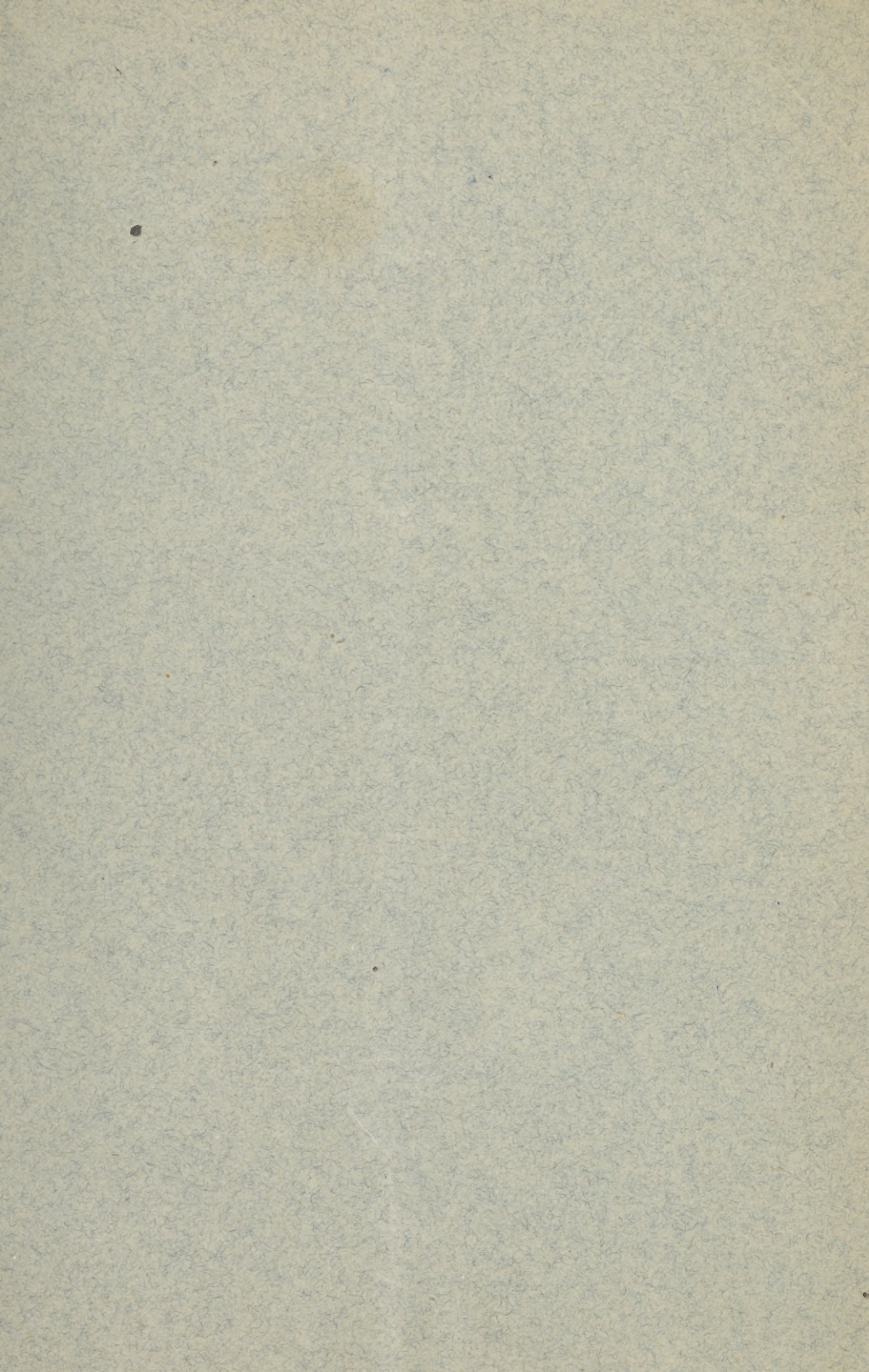
+ .75 + .5 c., vert.; L E + .75. These glasses were prescribed. December 21, 1888, comes to have the prescription duplicated. With the glasses the right side is wider, but the sides are made equal by adding + .75 to the left side, instead of + 1.5, which would be the average addition required.

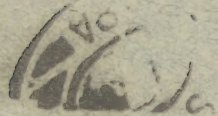
Other cases which I have recently examined show very little, if any, diminution of the metamorphopsys after the use of reading glasses for two or three years.

According to my experience, the phenomena coming under Group I, *unparallelism of the sides*, are more disturbing than those illustrated by Group II. In such cases when the correcting cylinder is strong—above 2 D,—it is desirable to compromise with a weaker lens; but the correct glass ought to be given just as soon as the patient will tolerate it. Changing the position of the axis of the cylinder is as unnecessary as it is unphilosophical.

In conclusion, I scarcely deem it necessary to prolong this article by further citation of cases illustrative of the foregoing remarks. To report all of the material bearing on this subject which has come under my notice, would be to fill a good-sized volume.

Besides, I am satisfied that the every-day experience of my colleagues will furnish them with all the cases of binocular metamorphopsys which they can possibly desire to investigate.





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